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**Heat exchanger, especially a charge-air cooler for
motor vehicles**

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The invention relates to a heat exchanger, especially a charge-air cooler for motor vehicles, according to the preamble of patent claim 1.

- 10 Known heat exchangers for motor vehicles, such as, for example, charge-air coolers and coolant radiators, are produced from aluminum (aluminum alloys) and soldered, this applying either only to the heat exchanger block or the entire heat exchanger, including header boxes.
- 15 The heat exchanger block, especially where charge-air coolers are concerned, is constructed from a series of flat tubes, between which corrugated ribs are arranged. The tube ends of the flat tubes are received in orifices, what are known as rim holes, of the tube
- 20 bottom and are soldered to the rim holes. This gives rise to a firm and leaktight tube/bottom connection. The header boxes are soldered or welded to the tube bottoms. For the connection between header box and tube bottom, the tube bottom has a peripheral edge strip
- 25 which engages over or under the header box and thus forms a soldering surface. The rim holes in the tube bottom extend over the entire depth of the latter, that is to say from longitudinal side to longitudinal side, there being between the narrow sides of the rim holes
- 30 and the edge strips a transitional region which has a channel-like, for example approximately U-shaped design. The tube bottom thus has an approximately rectangularly designed, if appropriate continuous channel which is composed of two parallel longitudinal

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sides and two parallel narrow sides. The longitudinal sides of the tube bottom are located opposite the narrow sides of the rim holes. During operation, the header boxes are loaded by the internal pressure of the heat exchange medium, for example compressed charge air. This gives rise, in the transitional region between the longitudinal sides of the tube bottom and the narrow sides of the rim holes, to deformations as a result of bending stresses which lead to stress peaks in the region of the narrow sides of the rim holes. The tube/bottom connection, in particular, is subjected to these stresses and deformations on its narrow side and in the tube corner regions in such a way that leaks of the heat exchanger may occur.

The object of the present invention is, in a heat exchanger of the type initially mentioned, to improve the tube/bottom connection and to avoid adverse stresses.

This object is achieved by means of the features of patent claim 1. According to the invention, a reinforcement is provided in the transitional region of the tube bottom. This affords the advantage that an inadmissible deformation or flexion of the tube bottom in the transitional region is avoided and the harmful stress peaks are reduced. The tube bottom, which, by being produced from a sheet steel billet, has approximately the same wall thickness in the remaining region, thus becomes deformable to a lesser extent on the longitudinal sides in the region of the tube narrow sides. The tube/bottom connection is consequently subjected to less or virtually no bending stress, but essentially to shearing stress, which constitutes an appreciably more favorable load.

The reinforcement of the transitional region may be implemented by means of various structural solutions which arise as advantageous refinements from the

subclaims. For example, the reinforcement may be configured as a material thickening, thus leading to an increased bending resistance for the transitional region. This could take place, in production terms, by means of the compression of the material. Another advantageous possibility for reinforcement is to reinforce the tube bottom in the transitional region, for example, by one or more beads. Thus, by stability being increased, with the wall thickness of the tube bottom remaining the same, an increased deformation resistance would be achieved. The beads are preferably to be arranged in the region of the narrow sides of the rim holes, in order to achieve an increased bending resistance there.

According to a further advantageous refinement of the invention, the reinforcement is designed as a profile strip which fills the channel-like transitional region and is soldered to the tube bottom. This profile strip likewise achieves a reinforcement, that is to say by means of an additional part which is connected to the tube bottom to form a bend-resistant region. Between the outer edge strip of the tube bottom and the narrow side of the rim hole, therefore, a connection, that is to say a firm bridge, is produced, which prevents a flexion or deformation of the transitional region. The harmful bending stresses are consequently "kept away" from the tube/bottom connection.

According to an advantageous development of the invention, the profile strip is produced or integrated in one piece with the header box, that is to say it forms a prolongation of the longitudinal edges of the header box downward, that is to say in the direction of the tube bottom. This does not entail any additional outlay in terms of manufacture or assembly, since the header box is placed onto the bottom and soldered to the latter, as hitherto.

According to a further refinement of the invention, the profile strip is designed as a (separate) insert strip, that is to say an additional part which is inserted into the channel-like transitional region and is soldered to the tube bottom. The advantage of this solution is that modifications do not have to be made either to the tube bottom or to the header box. For example, such insert strips may be used for heat exchangers, especially charge-air coolers, which are to be employed for higher charge-air pressures. Thus, by means of this simple purposeful measure, the same cooler can be adapted to the higher operating stresses.

In a further advantageous refinement of the invention, the profile or insert strips have toward the inside of the tube bottom, in the region of the tube narrow sides, recesses which partially surround the rim holes, that is to say bear against the narrow sides and corner regions and are supported with respect to these. Consequently, in particular, the corner regions of the tubes are also protected from harmful stress peaks.

Exemplary embodiments of the invention are illustrated in the drawing and are described in more detail below. In the drawing:

- fig. 1 shows a detail of a charge-air cooler,
- fig. 2 shows a view of the charge-air cooler according to fig. 1 with hatched insert strips,
- fig. 3 shows a sectional illustration of the charge-cooler according to fig. 1 and 2,
- fig. 4 shows a view of the tube bottom with hatched insert strips,
- fig. 4a shows a cross section through the tube bottom, and
- fig. 5 shows a further embodiment of the invention with an integrated profile strip.

Fig. 1 shows a detail, that is to say a "slice", of a charge-air cooler in the region of the charge-air box and of the tube/bottom connection. Charge-air coolers of this type are used for the cooling of compressed charge air in motor vehicles, especially commercial vehicles. A header box 1 (also called a charge-air box) has a U-shaped design in cross section and is preferably produced from aluminum alloy. Overall, the header box 1 has the form of an elongate box which can be produced by deep drawing or casting. The U-profile of the header box 1 has two legs 2, 3 which form the longitudinal sides of the charge-air box. The header box 1 is inserted into a tube bottom 4 which has, along the longitudinal sides, edge strips 5, 6 which are angled approximately perpendicularly with respect to a bottom plate 7. The bottom plate 7 has a multiplicity of rim holes, of which only one rim hole 8 receiving a tube end 9a of a flat tube 9 is illustrated here. The entire heat exchanger or charge-air cooler thus has a multiplicity of flat tubes, between which are arranged corrugated ribs, not illustrated, which form secondary heat exchange surfaces for ambient air. The legs 2, 3 of the box profile have, on their lower, that is to say open side, connecting portions 2a, 3a which overlap with the edge strips 5, 6 in the tube bottom 4 and are soldered to one another in this region. What are known as insert strips 10, 11, illustrated by hatching, are arranged below the lower edges of the connecting portions 2a, 3a.

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Fig. 2 shows the header box 1 according to fig. 1 as a front view, that is to say in a sectional plane in front of the rim hole 8. As is known from the prior art, the tube bottom 4 is produced from a sheet metal billet and therefore has essentially a constant wall thickness s ; the rim holes 8 are directed inward, that is to say toward the side of the box 1. The tubes 9 project with their tube ends 9a inward beyond the rim hole 8. In a further exemplary embodiment, not shown,

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the rim holes are directed outward. The tubes may in this case project beyond a tube bottom surface or advantageously terminate under such a tube bottom surface.

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The bottom plate 7 is planar on the longitudinal sides of the tube bottom 4, that is to say outside the rim holes 8, but has a channel-like design within the edge strips 5, 6, this channel merging, on the one hand, into the bottom plate 7 and, on the other hand, into the edge strips 5, 6, that is to say forming the transitional regions 12, 13. These transitional regions 12, 13 thus form longitudinal beads for increasing the stability of the tube bottom 4. By the box 1 being loaded by the internal pressure caused by the compressed charge air, this gives rise in the longitudinal sides 2, 3 of the box 1 to compressive and/or tensile forces which are transmitted to the edge strips 5, 6 of the bottom and bring about bending stresses and deformations in the transitional regions 12, 13. This is where the invention comes in with the arrangement of the insert strips 10, 11 which are designed as profile strips and have a profile which corresponds to that of the transitional regions 12, 13. The insert strips 10, 11 thus bear on the outside against the edge strips 5, 6, at the bottom against the channel-like transitional regions 12, 13 and on the inside against the narrow sides of the rim holes 8. Air gaps 14, 15 are left above the edge strips 10, 11. As already mentioned, the insert strips 10, 11, which preferably likewise consist of an aluminum alloy, are soldered to the bottom 4, that is to say in one operation with the entire heat exchanger.

35 Fig. 3 shows a sectional illustration in a plane parallel to the drawing plane according to fig. 2. In this illustration, in particular, the rim holes 8 can be seen clearly in their profile: the rim holes 8 form with the outer wall of the tube 9 an acute angle which

is filled with a solder meniscus 16 after soldering. Above the solder meniscus, the tube bears against the rim hole 8 with a relatively narrow gap. As mentioned, the rim hole 8 forms, with the two outer edge strips 5, 6 of the bottom, the transitional regions 12, 13 which here are in the form of an asymmetric U in cross section and are filled by the insert strips 10, 11. Between the edge strips 5, 6 and the rim holes 8, more precisely the narrow sides of the rim holes, the insert strips 10, 11 form a firm bridge which prevents a deformation of the transitional regions 12, 13. Consequently, the stress peaks occurring in the prior art are reduced, and the tube/bottom connection is relieved considerably in the region of the narrow sides. The pair box 1 can thus withstand higher pressures.

Fig. 4 shows a sectional illustration along the line IV-IV, as depicted in fig. 4a. Correspondingly to the form of the tubes 9, not illustrated here, the rim holes 8 have an approximately rectangular inner and outer cross-section with longitudinal sides 8a and narrow sides 8b. The insert strips 10, 11 fit snugly onto the narrow sides 8b of each rim hole, that is to say they have in the region of the narrow sides 8b recesses 10a, 11a in the form of the narrow sides 8b. This snug fit of the insert strips 10, 11 results, together with the soldering, in a very good support of the bottom regions located opposite one another, that is to say a bend-resistant interconnected structure. The recesses 10a, 11a may be produced by pressing.

Fig. 4a shows the tube bottom 4 in cross section, with the rim holes 8 which have an outer conical region 8c and an inner cylindrical region 8d (adapted to the cross section of the flat tubes 9). The conical region 8c also serves as an introduction slope for the tube ends 9a. The rim holes 8 are produced from the tube bottom plate 7 by hole-punch pressing (cf. fig. 2).

Fig. 5 shows a further embodiment of the invention, in which the insert strips described above are integrated with the air box, that is to say are produced in one piece with the latter here. The tube bottom 4 is unchanged; the header box 17 has connecting regions 17a, 17b, the lower edges of which are designed as profile strips 18, 19 which fill the channel-like transitional regions 12, 13 of the bottom 4. In principle, the same effect as that described above is achieved by means of this solution, that is to say a reinforcement of the transitional regions 12, 13. Insofar as the box 17 is produced as a casting or injection molding, the rounded profile strips 18, 19 may readily be produced by means of the corresponding configuration of the mold. In this design of the air box 17 with the profiled lower edges 18, 19, therefore, the insertion of the insert strips described above is dispensed with, that is to say one operation is saved. Similarly, the profile strips may also be fastened to the lower edges of the air box, for example by adhesive bonding.

Further solutions, not illustrated here, for reinforcing the transitional regions are possible, for example reinforcement by means of beads, that is to say an increase in the bending resistance by an appropriate shaping for increasing the moment of resistance. The beads may be formed in the region of the narrow sides of the rim holes at the same time as the production of the bottom. Furthermore, there is the possibility of designing the transitional region with a greater wall thickness, which may be carried out, for example, by compressing the bottom in the transitional region. These solutions, too, have the result that the harmful stress peaks in the region of the tube/bottom connection, that is to say in the region of the narrow sides and of the tube corner regions, are reduced.

Reference numerals

- 1 Charge-air box
- 2 Longitudinal side
- 2a Connecting region
- 3 Longitudinal side
- 3a Connecting region
- 4 Tube bottom
- 5 Edge strip
- 6 Edge strip
- 7 Bottom plate
- 8 Rim hole
- 8a Longitudinal side
- 8b Narrow side
- 8c Conical region
- 8d Cylindrical region
- 9 Flat tube
- 9a Tube end
- 10 Insert strip
- 11 Insert strip
- 12 Transitional region
- 13 Transitional region
- 14 Gap
- 15 Gap
- 16 Solder meniscus
- 17 Header box
- 17a Connecting region
- 17b Connecting region
- 18 Integrated profile strip
- 19 Integrated profile strip